he says, "I have always thought that there must have been a formative epoch, in which every creature had the power of special adaptation to its own needs—nay even to its own wishes or caprice. In this epoch of 'plasmation' when the so-called force of heredity—which tends to reproduction according to the type of the progenitor—had but little power, the world being still young, the organism must have been far more susceptible of modification by external forces (p. 36). . . . The actual power of adaptation in organisms is at the present day well nigh non-existent as compared with what they must have possessed in the past (p. 211). . . . The varied forms assumed by those groups of individuals called by naturalists species, would be merely the result of a plasmative force exerted by surrounding conditions on primitive beings (p. 208). . . . May it not be that the Rafflesia, and a host of other aberrant species, both animals and plants, are examples of the autocreation of organisms (derived from exceptional circumstances of the environment) and suddenly appeared *à l'improviste,* as it were, in that primitive epoch during which organic matter was easily plasmated, so as to adapt itself with facility even to extraordinary conditions of existence? (p. 389). . . . Therefore, contrary to the present prevailing tendency to attribute a powerful action to variability during the existing period, and to consider every species as inconstant, I hold the opposite opinion, namely, that at the present time species do not vary in Nature, returning thus to the old idea of the nearly absolute fixity of existing species (p. 210)." It is interesting to compare these views with those arrived at by Alfred Wallace, who wandered in the same jungles; and, as Dr. Guillemard, the English editor, rightly observes, "Whether the scientific reader does or does not admit the validity of all Dr. Beccari's theories concerning species-formation, he cannot call in question his abundant experience of the country, or his knowledge of the subjects of which he treats." A. C. H.

OILS FOR MOTOR-CARS.

POSSIBLY this article may be of interest to readers of NATURE who are not chemists, and therefore no apology need be made for treating certain parts of the subject in an elementary manner. The commercial names for motor-oils are numerous and confusing, and the automobilist may well be puzzled to discriminate between them, even if his chemistry has by no means become a mere schoolboy reminiscence.

The various liquids in use at the present time as fuels for motors are derived from three sources, namely, crude petroleum, coal tar, and alcohols. By far the largest quantity is furnished by the petroleum. Coal-tar "spirit" is scarcely beyond the experimental stage. Alcohol is somewhat largely used abroad, but at present is almost out of the question in this country.

Products from Crude Petroleum.—These, so far as motor fuel is concerned, are two: a *light oil* and a heavier or "*burning*" *oil.* The light oil, in one grade or another, is variously known as gasoline, petroleum spirit, petrol, petrol spirit, motor spirit, mineral spirit, motol, moto-essence, naphtha, petroleum-benzine, and benzoline. Of these, gasoline has the lowest density, benzoline the highest. The oil is obtained in the distillation of American crude petroleum, and may be said generally to be the portion of the distillate passing through the still between the temperature-limits of 60° C. and 150° C., and having a specific gravity ranging from 0·68 to 0·74. The limits, however, vary somewhat with the different refineries. To obtain a good motor "spirit" this fraction of the distillate is purified with sulphuric acid and with soda, and rectified by re-distillation. Such a spirit is clear, has no strong odour, and leaves no residue when evaporated from the hand. Two or three years ago the best English petrol had a specific gravity of 0·680; but, for reasons to be mentioned later, the density has been gradually raised, and is now generally about 0·720 or more.

Chemically, light oil or petrol is a mixture of several members of the homologous series of paraffin hydrocarbons, C_nH_{2n+2}. It is generally assumed to be mainly heptane, C_7H_{16}, and octane, C_8H_{18}, but both lower and higher members are usually present, and some analyses indicate that the range may commonly be from hexane, C_6H_{14}, to undecane, $C_{11}H_{24}$ A point to notice is that whilst petrol as a whole is a light, volatile oil, it is by no means a homogeneous liquid. The different hydrocarbons composing it have not the same volatility as one another, and they require different quantities of air for their complete combustion.

The heavier oil obtained from crude petroleum corresponds to what is ordinarily known as kerosene, petroleum oil, or paraffin. It is obtained by refining the fraction which distils between 150° and 200°, and has a density of about 0·78 to 0·81. This product contains higher members of the paraffin series than those of petrol. It is consequently less volatile, and has a higher flash-point.

Kerosene is not only cheaper than petrol, but safer in the handling. Why, then, is petrol used so largely as a motor fuel instead of kerosene? And why are some kinds of petrol better than others? To answer these questions we have to remember that, to form the proper explosive mixture for the engine, it is necessary to have the vapour of the liquid mixed with a particular proportion of air. With too little air the mixture burns too gently; with too much there is a diluent effect, and liability to failure of ignition. The ready volatility of petrol allows of the requisite mixture being made more easily, more certainly, and with a simpler form of carburetter than when kerosene is used. Failure to ignite is less frequent, and the combustion is cleaner.

Nevertheless, since the supply of petrol is not limitless, attempts are being made, with some success, to utilise kerosene as a source of motor energy. The principle employed is that of heating up the vapour of the kerosene, or the liquid itself, in order to allow of a readier admixture with the air in the carburetter. This is effected either by the heat of the exhaust or by some other special contrivance. A "smokeless petroleum engine" has recently been described which is said to run without smoke or smell, and without "sooting" the cylinder. It will not, however, start with the cold kerosene. Petrol is used for the first revolutions in order to heat the vaporiser and raise the kerosene to the necessary temperature.

As regards differences of quality met with in motor spirits (petrol), the first thing to notice is that the higher the density of the liquid the nearer does it approach to the character of kerosene and to the possession of the disadvantages peculiar to the latter. To meet the growing demand, makers have been more and more inclined to eke out their supply of petrol by including a portion of the heavier fractions that were formerly rejected. Hence many of the present oils are to that extent of inferior quality. Next, the density alone is not an infallible criterion, because a spirit having a density of, let us say, 0·700, may be made up in different ways. Ideally, it might consist of a single hydrocarbon having the density in question. On the other hand, it might be compounded of two hydrocarbons having widely different densities, such as 0·660 and 0·740 respectively. In the first case it would distil completely at one uniform temperature, in the second there would be a difference of perhaps a hundred

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degrees between the initial and the final boiling points. With homologous hydrocarbons the lower-boiling member vaporises more readily than the higher; consequently, in practice, the vapour from the second spirit would in the early stages of a run contain an excessive proportion of the more volatile constituent, and in the later stages too much of that which is less volatile. For satisfactory combustion these two constituents require very different proportions of air; hence if the carburetter was initially arranged to give the proper quantity it would not do so in the later stages. The practical bearing is that, to avoid waste of fuel or loss of heat, more attention must be paid to the carburetter when the petrol has a wide range of boiling points than when it is more nearly homogeneous.

As already mentioned, the petrols in actual use consist of several hydrocarbons; there is none containing only one, or even only two. But the foregoing examples typify the better and the inferior qualities respectively.

Products from Coal-tar.—These are known commercially as benzol or benzole, benzine, and coal-tar spirit, all of which terms mean nearly the same thing, and toluol, which is a very similar liquid of lower density. (Benzol or benzine should be distinguished from benzoline, the petroleum product previously referred to.) In the first group the aromatic hydrocarbon benzene, C_6H_6, is the chief constituent, but toluene, C_7H_8, and xylenes, C_8H_{10}, also accompany it. Benzol is commercial benzene, *i.e.* benzene with some impurities and homologues; benzine is a cruder variety; these differ only in the proportions of the admixtures, and are often indistinguishable the one from the other. Coal-tar spirit is a general term for either. In America and in France, as well as sometimes in this country, the term "benzine" refers to the petroleum naphtha, not to the coal-tar product.

Benzol has a greater density than petrol (about 0.883 at 15°.5 C.), and a higher boiling point, viz. about 90° C. Nevertheless, it has the advantage of distilling, as a whole, within much narrower limits than most varieties of petrol do. Thus, while there may be a difference of more than 100° C. between the initial and final boiling points of petrol, a good sample of "90's benzol" will distil completely within a range of about 55° C. or less, *i.e.* between 90° and 145°. Benzol is consequently more like the ideal homogeneous fuel than petrol is, and this, together with the necessity of supplementing the supply of petrol by some other fuel, has led to its frequent employment abroad and to experimental trials in this country. Deutz benzol locomotives have been used for some time in Germany, and the tram-cars of the Saalgau-Herbertingen-Riedlingen line are worked by a 14 h.p. benzol motor, whilst a mixture of benzol and alcohol is used in some of the French racing cars. So far as the German experience has gone, the results are said to indicate that the benzol motor is about 10 per cent. cheaper in working than the alcohol engine. The British trials seem to show that benzol works more uniformly than petrol, and is generally satisfactory, except that with too great a compression in the cylinders there is a liability to pre-ignition.

One disadvantage of benzol is the presence in it of sulphur compounds, chiefly carbon disulphide and thiophene. These not only give an evil-smelling exhaust, but may conceivably corrode the metal of the cylinder through the formation of acid vapours in the combustion. Probably at a cost of about a penny per gallon the benzol could be sufficiently freed from sulphur, and it is thought that, with a good demand, the purified liquid might be supplied at a price of about 7*d.* a gallon, or less. Unfortunately, however, the supply of benzol is even more limited than that of petrol; the yield from coal-tar is only some 0.6 per cent., and much of what could be produced is already absorbed by the chemical and dye industries. It seems, therefore, very unlikely that benzol will ever largely supplant petrol, though it may usefully supplement this fuel.

Toluol (crude toluene), of lower density but higher boiling point than benzol, has also been recently tried, though not on a sufficiently extended scale to give much practical information. Benzol is essentially a mixture of pure benzene and toluol, and in one respect the mixture is better than pure benzene, because the latter freezes at 0° C., and this is prevented by the presence of toluol.

Alcohols as Fuels.—The industrial side of the question has encouraged the use of alcohol in France and Germany, since, other things being equal, it is better to support home agriculture than foreign oil-fields. Strong alcohol can be bought in Germany at a cost of 8½*d.* to 10*d.* per gallon, and at this price its use is said to be economical compared with petrol. Pure alcohol, of course, is heavily taxed—in this country the duty amounts to 17*s.* per gallon of 90 per cent. alcohol—and that used for motor purposes is "denatured" by the addition of foreign substances. In England the denatured product is methylated spirit, obtained by mixing "spirits of wine" with not less than one-ninth of its bulk of wood-naphtha, and when intended for retailing, with 0.38 per cent. of mineral naphtha or petroleum oil in addition. In France the denaturant is a mixture of heavy "benzine" and malachite green. Ordinary methylated spirit, in some experiments made a short time ago, was said to give an exhaust with an odour so vile as would preclude its general use; this is attributed to the denaturant, and to obviate it one suggestion is that alcohol intended for motor-fuel should be denatured with petrol. There are, however, some fiscal difficulties in the way.

Alcohol is a substance already partly oxidised; it contains rather less hydrogen than does petrol, and only about one-half as much carbon, the difference being made up of oxygen. Consequently its available heat-energy, viz. the heat developed by the complete oxidation of its carbon and hydrogen, is not much more than one-half that of good petrol. Nevertheless, it has some compensations. It is of nearly uniform composition, and distils within much narrower limits than petrol; in fact, strong alcohol, not denatured, is an almost homogeneous body, which boils away completely at a practically constant temperature. Moreover, it is claimed that the alcohol engine has a much greater efficiency than the petrol motor. To get the best results, however, it has been found necessary to use a higher compression than that given by the ordinary petrol engine. In some cases both petrol and alcohol are employed, with two carburetters; the petrol is used for starting, and is automatically cut off by a governor when the motor is sufficiently hot. The net result of the alcohol trials at present seems to be that, for equal volumes, petrol is appreciably more efficient than denatured alcohol; but the difference is not considerable, and fluctuations in price may yet make alcohol a serious competitor with petrol where the fiscal difficulties can be overcome.

The cheaper higher alcohols of fusel oil (chiefly amyl and butyl alcohols) have also been proposed for use as motor-fuels. But practical trials are lacking, and in any case the supply of fusel oil is only a limited one. For the principal motor-fuel of the future it is probably to kerosene that we must look.

C. SIMMONDS.

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